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MILITRAN REFERENCE MANUAL

Prepared for the

OFFICE OF NAVAL RESEARCH
NAVY DEPARTMENT
WASHINGTON, D. C.

and the

DIRECTORATE OF COMPUTERS
ELECTRONIC SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
L. G. HANSCOM FIELD, BEDFORD, MASS.

U. S. Navy Contract No. Nonr 2936(00)

by

SYSTEMS RESEARCH GROUP, INC.
1501 Franklin Avenue
Mineola, L. I., New York

JUNE 1964

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FOREWORD

This is one of three technical reports being published simultaneously. The others are the MILITRAN Operations Manual for IBM 7090-7094 (Technical Documentary Report No. ESD-TDR-64-389) and the MILITRAN Programming Manual (Technical Documentary Report No. ESD-TDR-64-320). The three reports constitute a complete description and instructions for using the MILITRAN language in computer programming of simulation problems.

The MILITRAN 7090-7094 Processor, which is used to compile a problem written in MILITRAN source language into a machine language program, will be available to prospective users. Pending final arrangements, requests for information about the MILITRAN Processor should be sent to the Office of Naval Research (Code 491).

This report was prepared by the Systems Research Group, Inc., under Contract Nonr-2936(00), which was initiated by the Naval Analysis Group, Office of Naval Research, and has been jointly supported by the Office of Naval Research and the Electronic Systems Division, Air Force Systems Command.

ABSTRACT

MILITRAN is an algorithmic computer language specifically oriented to the problems encountered in simulation programming. In addition to providing overall flexibility in expressing complex procedures, the language contains features which greatly simplify the maintenance of status lists, handling of numeric and non-numeric data, and sequencing of events in simulated time.

This report is intended as a reference summary for those already familiar with MILITRAN.

REVIEW AND APPROVAL

This Technical Documentary Report has been reviewed by the Electronic Systems Division, U. S. Air Force Systems Command, and is approved for general distribution.



J. B. CURTIS
2nd Lt., USAF
PROJECT OFFICER

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INTRODUCTION

This manual is designed as a reference for programmers working in MILITRAN. The description of the MILITRAN language herein is more concise than that given in the MILITRAN PROGRAMMING MANUAL, with which the reader is assumed to be familiar.

Various sections of this manual outline GENERAL LANGUAGE CHARACTERISTICS, statements which define program STRUCTURE, characteristics of EXPRESSIONS, and statements whose major functions include PROCESSING, INPUT OUTPUT, CONTROL, and operation of the COMPILER.

A summary of all MILITRAN forms is included in the appendix.

GENERAL LANGUAGE CHARACTERISTICS

A MILITRAN source program is a series of MILITRAN statements which specify a sequence of operations to be performed by a digital computer. A program is either a main program or a procedure. A main program initiates processing and may be devised in such a way as to require no procedures. A procedure cannot initiate processing and must receive a signal from either a main program or another procedure before its operation sequence can be executed.

A MILITRAN statement is a string of elements arranged in a prescribed order which specifies one or more of the following characteristics of the program:

1. STRUCTURE of the program
or its elements;
2. PROCESSING to be performed
within the computer;
3. INPUT/OUTPUT, or exchange
of data between the computer
and its external storage devices;
4. CONTROL of the sequence in
which various operations are
to be performed; and

5. COMPILER instructions, or
specification of the manner
in which the translation from
MILITRAN to machine language
is to be performed.

The elements which combine to form MILITRAN statements are names, constants, punctuation marks, statement type identifiers, operators, and mnemonic delimiters. These elements are in turn made up of characters, which are the basic units of any language.

Characters

The MILITRAN Basic Language is expressed in terms of the following character set:

ABCDEFGHIJKLMNØPQRSTUVWXYZ
0123456789.(), = + - * /

The character "blank" is normally not significant in the language. Except where specifically noted in this summary, blanks may be used in any part of a statement without any effect on the statement.

"Alphabetic characters" include the letters A through Z; "numeric characters" include the digits 0 through 9; alphanumeric characters include both alphabetic and numeric characters. All others are "special characters."

Names

A name is a string of one to sixty alphameric characters, the first of which is alphabetic. Although statement type identifiers and mnemonic delimiters are alphabetic strings, their use within a statement distinguishes them from names without ambiguity.

Certain names have a pre-defined meaning in MILITRAN and may be used only in reference to that meaning.

These names are:

ABS	GST	PRINTER
ATAN	INDEX	RANDØM
ATTACKER	INTEGER	RANDØM INDEX
CARDS	LENGTH	REAL
CØS	LØG	SIGN
EACH	LST	SIN
END CØMPILATIØN	MAX	SQRT
EPSILØN	MIN	TAN
EXP	MINIMUM INDEX	TARGET
FALSE	MØD	TIME
FØRMAT	NEXT EVENT	TRUE

All names used in a MILITRAN source program are either explicitly or implicitly assigned a type. Some types of names are assigned a mode. The type of a name

indicates the nature of its use in the program. The mode of a name indicates the form of data referred to by the name.

The following table lists all possible types of names, whether or not they have modes, and short descriptions of their use in a program.

<u>Type</u>	<u>Mode?</u>	<u>Use in Program</u>
Single Variable	Yes	Storage of single items of data.
Array	Yes	Storage of several items of data under a single name.
Vector	Yes	Storage of several arrays under a single name.
List	Yes	Special form of vector which permits automatic updating of data items.
Object	No	Specification of basic identifiers.
Class	No	Grouping of objects.
Contingent Event with List	Yes	Association of processing functions with a list of the same name.
Permanent Event	No	Linking of processing functions in a simulated time sequence.
Permanent Event with List	Yes	Association of processing functions with a list of the same name.
Vector Component	Yes	An array which is associated with a vector of list.
Symbolic Dimension	Yes	Specification of array dimensions.
Statement Label	No	Designation of points in program.
Procedure	Yes	Designation of subroutine entry.
Open Procedure	Yes	Designation of integral processing codes.
External Procedure	Yes	Designation of separately coded processing.

Constants

Constants are single items of data whose value is unchanged throughout the execution of the program. In fact, a constant might be thought of as a nameless single variable.

Integer constants may take one of the following forms:

1. A string of numeric characters.
2. A string of the form "nHxxxxxx" where n is a digit not exceeding 6 and x is any character including the character "blank". The number of characters (x) must be equal to n.

Real constants may take one of the following forms:

1. A string of numeric characters which includes one and only one period.
2. A string of numeric characters, which may or may not include a period, followed by E, En, Enn, En, or Enn, where n is a numeric character.

The distinction between real and integer constants is significant only in arguments to procedures.

Logical constants include only the names TRUE and FALSE.

Punctuation Marks

The only punctuation marks used in MILITRAN are the following:

.	Period
(Open Parentheses
)	Close Parentheses
,	Comma
...	Ellipsis (Delimits comments)

Operators

The operators used in MILITRAN are the following:

=	Substitution
+	Addition; plus
-	Subtraction; minus
*	Multiplication
/	Division
.P.	Exponentiation
.E.	Comparison: Equal to
.G.	Comparison: Greater than
.L.	Comparison: Less than
.NE.	Comparison: Not equal to
.GE.	Comparison: Greater than or equal to
.LE.	Comparison: Less than or equal to
.IS.	Object identity
.IN.	Object inclusion

.ØR.	Logical disjunction
.NØT.	Logical negation
.AND.	Logical conjunction
.EQV.	Logical equivalence
.EXØR.	Logical exclusive disjunction

Mnemonic Delimiters

The delimiters BY, BY ENTRY, CØNTAINS, FØR, FRØM, IN, TØ, and UNTIL are used within certain statements. Use of these alphameric combinations as names is permitted, as the distinction between name and delimiter is always contextually clear.

Statement Type Identifiers

The basic statement in MILITRAN involves substitution of one data item for another within the computer. The substitution statement has the form

$$a = b$$

where a is a subscripted or unsubscripted variable name and b is any expression whose value is suitable for storage in a.

All statements which are not substitution statements are designated by alphabetic strings called statement type identifiers. The following table lists all statement types and their primary uses. The form and characteristics of each statement is summarized in later sections by primary use. Primary functions are listed under GENERAL LANGUAGE CHARACTERISTICS.

<u>Statement Type</u>	<u>Primary Function</u>
BACKSPACE	INPUT/OUTPUT
BACKSPACE FILE	INPUT/OUTPUT
BINARY READ	INPUT/OUTPUT
BINARY WRITE	INPUT/OUTPUT
CLASS	STRUCTURE
CØMMØN	STRUCTURE
CØNTINGENT EVENT	STRUCTURE
CØNTINUE	CONTROL
DØ	CONTROL
END	CONTROL
END CØMPILATIØN	COMPILER
END CØNTINGENT EVENTS	CONTROL
END FILE	INPUT/OUTPUT
END FILE RETURN	CONTROL
END RECØRD RETURN	CONTROL
EXECUTE	CONTROL
FØRMAT	INPUT/OUTPUT
GØ TØ	CONTROL
IF	CONTROL
INTEGER	STRUCTURE
LIST	STRUCTURE
LØGICAL	STRUCTURE
NEXT EVENT	CONTROL
NEXT EVENT EXCEPT	CONTROL

<u>Statement Type</u>	<u>Primary Function</u>
NORMAL MODE	STRUCTURE
OBJECT	STRUCTURE
PAUSE	CONTROL
PERMANENT EVENT	STRUCTURE
PLACE	PROCESSING
PLACE ENTRY	PROCESSING
PROCEDURE	STRUCTURE
PROGRAM OBJECT	STRUCTURE
READ	INPUT/OUTPUT
READWRITE	INPUT/OUTPUT
REAL	STRUCTURE
REMOVE	PROCESSING
REMOVE ENTRY	PROCESSING
REPLACE	PROCESSING
REPLACE ENTRY	PROCESSING
RESET LENGTH	PROCESSING
RETURN	CONTROL
REWIND	INPUT/OUTPUT
STOP	CONTROL
SUSPEND FAP LISTING	COMPILER
UNLESS	CONTROL
UNLOAD	INPUT/OUTPUT
VECTOR	STRUCTURE
WRITE	INPUT/OUTPUT

STRUCTURE

Structure - defining statements are summarized in this section. They include:

CLASS	OBJECT
COMMON	PERMANENT EVENT
CONTINGENT EVENT	PROCEDURE
INTEGER	PROGRAM OBJECT
LIST	REAL
LOGICAL	VECTOR
NORMAL MODE	

Object

The statement

$$\text{OBJECT } n_1(d_1), n_2(d_2), \dots, n_m(d_m)$$

defines names n_1, n_2, \dots, n_m to represent basic object types. The names are preserved for use at running time in input/output operations.

Dimension d_1 designates the number of objects to be named n_1 . This dimension may be an expression of real or integer mode. Names used in a dimension are defined by such use to be symbolic dimensions, and no other declaration of type or mode is permitted except subsequent use in dimensions.

Class

The statement

CLASS (n) CØNTAINS a_1, a_2, \dots, a_m

defines the name n to be that of a class. The name is not preserved in its external form.

The members of the class are specified by elements a_1, a_2, \dots, a_m , where a_1 may have the following forms:

object name

EACH*object name

class name

EACH*class name

Object and class names used in a_1, a_2, \dots, a_m must have been declared as such by statements appearing before the current CLASS statement.

The use or absence of "EACH*" indicates whether or not membership is individual as opposed to collective.

Real, Integer, Logical, Program Object

The statements

REAL a_1, a_2, \dots, a_m

INTEGER a_1, a_2, \dots, a_m

LOGICAL a_1, a_2, \dots, a_m

PROGRAM OBJECT a_1, a_2, \dots, a_m

where element a_1 may have the form n_1 or $n_1(d_1, d_2, \dots, d_k)$, defines names n_1, n_2, \dots, n_m to be of REAL, INTEGER, LOGICAL, or PROGRAM OBJECT mode.

The appearance of dimensions (d_1, d_2, \dots, d_k) in the element a_1 further defines name n_1 to be an array having k dimensions.

Dimensions (d_1, d_2, \dots, d_k) may each assume the following forms:

1. An expression of real or integer mode;
2. An object name; or
3. A class name.

Any name which appears in a dimension is defined by such appearance to be a symbolic dimension unless it is defined elsewhere as an object or class. No other definition of symbolic dimensions is permitted except subsequent use in another dimension.

Normal Mode

In the absence of explicit mode declarations, names are assigned modes according to their initial letters as required. The correspondence of modes to initial letters is known as the "normal mode".

The statement

$$\begin{aligned} \text{NØRMAL MØDE } m_1(a_1, a_2, \dots, a_i), m_2(b_1, b_2, \dots, b_j), \\ m_3(c_1, c_2, \dots, c_k), \dots, m_r \end{aligned}$$

is used to specify the normal mode. Mode designators m may be the words REAL, INTEGER, LØGICAL, or PRØGRAM ØBJECT . Alphabetic characters $a_1, a_2, \dots, b_1, b_2, \dots, c_k$ indicate the initial letters which are to correspond to the various mode designators. Designator m_r applies to all letters not explicitly mentioned in the statement, and is assumed REAL if absent.

The normal mode so defined will prevail until another NØRMAL MØDE statement is encountered. The initial normal mode for all programs is REAL.

Vector, List

The statements

VECTØR $n((c_1, c_2, \dots, c_j), d_1, d_2, \dots, d_k)$, etc.

LIST $n((c_1, c_2, \dots, c_j), d_1)$, etc.

define groups of arrays c_1, c_2, \dots, c_j which have identical dimensions d_1, d_2, \dots, d_k and are grouped together under the name n . The name n is declared to be a vector or list, and names c_1, c_2, \dots, c_j are declared to be vector components. The number of such name/component/dimension groups which can be declared in one statement is limited only by the maximum statement length.

Unless the mode of name n is declared explicitly in a REAL, INTEGER, LOGICAL, or PROGRAM OBJECT statement, the normal mode prevailing at the appearance of the VECTØR or LIST statement will be assigned. Components whose modes are not explicitly defined will be assigned the mode of the name n .

Dimensions d_1, d_2, \dots, d_k may assume the same form as array dimensions previously described.

Only two differences obtain between vectors and lists:

1. Lists may have only one dimension; vectors may have any number.
2. Lists may be operated on by special processing statements; vectors may not.

Contingent Event, Permanent Event

The statements

CØNTINGENT EVENT $n((c_1, c_2, \dots, c_j), d_1)$

PERMANENT EVENT $n((c_1, c_2, \dots, c_j), d_1)$

PERMANENT EVENT n

declare the name n to be a contingent event with list, permanent event with list, or permanent event. Forms with a list create storage assignments exactly as would a LIST statement.

The event statement is always followed by a series of one or more statements, the last of which must be an END statement. (See CONTROL.) This series of statements embodies the processing associated with the event named n .

Standard event processing algorithms require the components c_1, c_2 , and c_3 of a CØNTINGENT EVENT list to have modes of REAL, PRØGRAM OBJECT, and PRØGRAM ØBJECT respectively. Any other construction may be used where standard processing is not.

Common

The statement

COMMON n_1, n_2, \dots, n_k

causes storage required by data items named n_1, n_2, \dots, n_k to be placed in a special area of the computer so that it can be directly accessed by procedures. Additions to this common store are cumulative, items from one common statement being added to those from any previous common statement.

Access to common data by more than one program requires that each program have identical common structure, i.e.:

1. Each item in common must be identically defined in both programs;
2. Common statements in both programs must specify these items in identical order.

Identical definition and order suggest the following rules for common structure:

1. If an item in common has symbolic dimensions, the dimension names should also be in common;

2. If an item in common has dimensions which are object or class names, those names should also be in common;
3. If a PERMANENT EVENT with list is in common, the corresponding item in all programs except that containing the event processing should be declared as a LIST.
4. If a CØNTINGENT EVENT with list is in common, the corresponding item in all programs except that containing the event processing should be declared as a LIST and preceded in common by a single variable which is otherwise unused. This extra variable does not appear in the common statements of the program containing the event processing.

Only certain types of names may appear in a common statement, and these types are:

Single variable

Array

Vector

List

Object
 Class
 Contingent event with list
 Permanent event with list
 Symbolic dimension

The names TIME, ATTACKER, TARGET, or INDEX may not appear in a common statement. Appearance of the name NEXT EVENT in a common statement will place all of the above names in common.

Procedure

The statement

PRØCEDURE $n(a_1, a_2, \dots, a_m)$

designates the entire program in which it appears to be a procedure whose name corresponds to the first six (or less) characters of the name n . Neither the name n nor another PRØCEDURE statement may appear elsewhere in the same program.

The names a_1, a_2, \dots, a_m and their enclosing parentheses are optional, and designate the dummy arguments to the procedure if present. The following types of names may be used as dummy arguments:

Single variable
 Array
 Vector
 List
 Object

Class

Contingent Event with list

Permanent Event with list

Symbolic dimension

Statement label.

EXPRESSIONS

As many MILITRAN statements depend upon the use of expressions, a brief summary of expression forms and types is presented in this section. A short discussion of retrieval forms is also included.

Expression Syntax

The overall syntax of expressions is presented here in the familiar Backus type notation.

Brackets $\langle \rangle$ used below enclose terms designating elements; the sign $::=$ may be read as "takes the form"; vertical lines may be read as "or"; and all other characters represent themselves.

$$\langle \text{expression} \rangle ::= \langle \text{arithmetic expression} \rangle \mid \langle \text{logical expression} \rangle \\ \langle \text{program object expression} \rangle$$

$$\langle \text{arithmetic expression} \rangle ::= \langle \text{real expression} \rangle \mid \langle \text{integer expression} \rangle$$

$$\langle \text{arithmetic operator} \rangle ::= + \mid - \mid * \mid / \mid .P.$$

$$\langle \text{arithmetic comparator} \rangle ::= .E. \mid .G. \mid .L. \mid .NE. \mid .GE. \mid .LE.$$

$$\langle \text{logical operator} \rangle ::= .\emptyset R. \mid .AND. \mid .EQV. \mid .EX\emptyset R.$$

$\langle \text{real expression} \rangle ::= \langle \text{real data item} \rangle \mid + \langle \text{real expression} \rangle \mid$
 $- \langle \text{real expression} \rangle \mid (\langle \text{real expression} \rangle) \mid$
 $\langle \text{real expression} \rangle \langle \text{arithmetic operator} \rangle \langle \text{real expression} \rangle \mid$
 $\langle \text{integer expression} \rangle \langle \text{arithmetic operator} \rangle \langle \text{real expression} \rangle \mid$
 $\langle \text{real expression} \rangle \langle \text{arithmetic operator} \rangle \langle \text{integer expression} \rangle$

$\langle \text{integer expression} \rangle ::= \langle \text{integer data item} \rangle \mid + \langle \text{integer expression} \rangle \mid$
 $- \langle \text{integer expression} \rangle \mid (\langle \text{integer expression} \rangle) \mid$
 $\langle \text{integer expression} \rangle \langle \text{arithmetic operator} \rangle \langle \text{integer expression} \rangle$

$\langle \text{logical expression} \rangle ::= \langle \text{logical data item} \rangle \mid .\text{NOT}. \langle \text{logical expression} \rangle \mid$
 $\langle \text{logical expression} \rangle \langle \text{logical operator} \rangle \langle \text{logical expression} \rangle \mid$
 $\langle \text{arithmetic expression} \rangle \langle \text{arithmetic comparator} \rangle \langle \text{arithmetic expression} \rangle \mid$
 $\langle \text{program object expression} \rangle .\text{IN}. \langle \text{object or class name} \rangle \mid$
 $\langle \text{program object expression} \rangle .\text{IS}. \langle \text{program object expression} \rangle \mid$
 $(\langle \text{logical expression} \rangle)$

$\langle \text{program object expression} \rangle ::= \langle \text{program object data item} \rangle \mid$
 $\langle \text{object or class name} \rangle (\langle \text{arithmetic expression} \rangle) \mid$
 $(\langle \text{program object expression} \rangle)$

$\langle \text{data item} \rangle ::= \langle \text{single variable name} \rangle |$
 $\langle \text{symbolic dimension name} \rangle |$
 $\langle \text{subscripted array name} \rangle |$
 $\langle \text{subscripted vector name} \rangle |$
 $\langle \text{function} \rangle | \langle \text{constant} \rangle$

$\langle \text{subscripted array name} \rangle ::= \langle \text{array-type name} \rangle (\langle \text{subscript list} \rangle)$

$\langle \text{subscripted vector name} \rangle ::= \langle \text{vector-type name} \rangle (\langle \text{subscript list} \rangle , \langle \text{arithmetic expression} \rangle)$

$\langle \text{array-type name} \rangle ::= \langle \text{array name} \rangle | \langle \text{vector component name} \rangle$

$\langle \text{vector-type name} \rangle ::= \langle \text{vector name} \rangle | \langle \text{list name} \rangle |$
 $\langle \text{contingent-event-with-list name} \rangle |$
 $\langle \text{permanent-event-with-list name} \rangle$

$\langle \text{subscript list} \rangle ::= \langle \text{subscript} \rangle | \langle \text{subscript list} \rangle , \langle \text{subscript} \rangle$

$\langle \text{subscript} \rangle ::= \langle \text{arithmetic expression} \rangle | \langle \text{program object expression} \rangle$

$\langle \text{function} \rangle ::= \langle \text{external procedure name} \rangle (\langle \text{argument list} \rangle) |$
 $\langle \text{open procedure name} \rangle (\langle \text{argument list} \rangle) |$
 $\langle \text{external procedure name} \rangle | \langle \text{open procedure name} \rangle$

$$\langle \text{argument list} \rangle ::= \langle \text{argument} \rangle \mid \langle \text{argument list} \rangle , \langle \text{argument} \rangle$$

$$\begin{aligned} \langle \text{argument} \rangle ::= & \langle \text{expression} \rangle \mid \langle \text{vector-type name} \rangle \\ & \langle \text{array-type name} \rangle \mid \langle \text{object or class name} \rangle \mid \\ & \langle \text{statement label name} \rangle \end{aligned}$$

Functions

A function is a procedure whose execution is implied by its use in an expression. Execution of the function always returns a single value which replaces the function in the expression.

Arguments to a function must correspond in type and order to those expected by the procedure.

A name whose type is not otherwise declared is implicitly declared to be an external procedure (function) when it appears with an argument list in an expression.

Standard Functions

Several functions are pre-defined in MILITRAN, and reference to their names automatically produces either open coding or calling sequences to library subroutines. These functions are described below. Values are returned in the same mode as the arguments except where noted. Arguments must be REAL except where noted.

ABS (v) returns $|v|$. The argument v may be either REAL or INTEGER.

ATAN (v_1, v_2) returns the angle α whose tangent is v_1/v_2 .
($0 \leq \alpha < 2\pi$).

COS (v) returns $\cos v$.

EPSILON (v) returns $(v + \epsilon)$ where ϵ is the smallest increment physically recognizable in v. Argument v may be either REAL or INTEGER.
($\epsilon \equiv 1$ when v is integer.)

EXP (v) returns e^v where e is the Napierian base.

INTEGER (v) returns the largest integer i such that $|i| \leq |v|$. Argument v may be either REAL or INTEGER. Result i is returned in INTEGER mode.

LOG (v) returns the natural logarithm of v .

MAX (v_1, v_2, \dots, v_j) returns the maximum value among the arguments (v_1, \dots, v_j). Arguments may be REAL or INTEGER.

MIN (v_1, v_2, \dots, v_j) returns the minimum value among the arguments (v_1, \dots, v_j). Arguments may be REAL or INTEGER.

RANDOM returns a REAL pseudo-random value, v , ($0 \leq v < 1$).

REAL (v) returns the value of v in REAL mode. The argument v may be either REAL or INTEGER. ($|v| < 2^{27}$.)

SIGN (v₁, v₂) returns the value

$$|v_1| \cdot \frac{|v_2|}{v_2} \text{ if } v_2 \neq 0, \quad |v_1| \text{ if } v_2 = 0.$$

SIN (v) returns sin v.

SQRT (v) returns $\sqrt{|v|}$

TAN (v) returns tan v.

(Values exceeding the maximum possible REAL value are truncated to that maximum.)

Subscripts

Retrieval of specific data items from arrays and vectors is accomplished by means of subscripts. Types of names requiring subscripts fall into two groups as follows:

<u>Array-type</u>	<u>Vector-type</u>
Array	Vector
Vector component	List
	Contingent event with list
	Permanent event with list

Array-type names require exactly as many subscripts as they have dimensions. Consider the statement

REAL $n(d_1, \dots, d_1, \dots, d_m)$

which defines the name n to be an m -dimensional array. Retrieval of a single member of n would be accomplished by the expression

$n(e_1, \dots, e_1, \dots, e_m)$

occurring elsewhere in the program. The expressions e_1, \dots, e_m are subject to the following rules:

1. Any expression e_1 may be an arithmetic expression.
2. Expression e_1 may be a program object expression if and only if dimension d_1 is an object or class name.

Vector-type names require one more subscript than they have dimensions. Consider the statement

$$\text{VECTOR } n((c_1, \dots, c_j, \dots, c_k), d_1, \dots, d_1, \dots, d_m)$$

which defines the name to be an m -dimensional vector having k components. Retrieval of a single member of n would be accomplished by either of the expressions

$$n(e_1, \dots, e_1, \dots, e_m, e_{m+1})$$

$$c_j(e_1, \dots, e_1, \dots, e_m)$$

occurring elsewhere in the program. The expressions e_1, \dots, e_m are subject to the same rules as are subscripts for array-type names. The expression e_{m+1} must be arithmetic and equal to j .

PROCESSING

Processing statements are summarized in this section. They include:

PLACE	REPLACE
PLACE ENTRY	REPLACE ENTRY
REMOVE	RESET LENGTH
REMOVE ENTRY	Substitution

Substitution

All substitution statements take the form

$$a = b$$

where a is a subscripted or unsubscripted name and b is an expressions. The name "a" may not be an object, class, permanent event without list, statement label, procedure, external procedure, or open procedure.

The following processing may be accomplished through a substitution statement:

1. If a and b are of the same mode, the value of expression b replaces the value of a.
2. If a and b are both subscripted vector-type names, the contents of b replace the contents of a without regard to mode. ("Contents" as used above refers only to a single value, not the entire array.)
3. If a is real and b is integer, the value of expression b is converted to a real number

and replaces the value of a.

4. If a is integer and b is real, the value of expression b is truncated to an integer and replaces the value of b.

Conditions 3 and 4 above apply only when condition 2 does not.

List Processing

Vector-type names defined in LIST, CONTINGENT EVENT, and PERMANENT EVENT statements represent groups of values which may be processed by means of special "list processing statements."

In the discussion of list processing statements which follows, all descriptions will refer to the generalized lists defined by

$$\text{LIST } m((m_1, \dots, m_1, \dots, m_j), d_m), n((n_1, \dots, n_1, \dots, n_k) d_n)$$

The symbols designating the lists and components defined above will be maintained throughout the discussion.

List Entries

The list m may contain d_m entries. The e^{th} entry in list m is the set of values.

$$m_1(e), m_2(e), \dots, m_j(e)$$

The current number of entries in list m is represented by the function

$$\text{LENGTH}(m)$$

which is initially equal to zero for all lists.

Any value in the group represented by the name m may be altered by means of a substitution statement. However, substitution statements do not maintain the LENGTH function and list processing statements consider the e^{th} entry valid only if $1 \leq e \leq \text{LENGTH}(m)$.

List Processing Conditions

Several statements and functions involved in list processing depend upon logical conditions of the form

$$(b_1, b_2, \dots, b_k, b_x)$$

where k is the number of components in the list.

The e^{th} entry of list n is said to meet the condition (b_1, \dots, b_k, b_x) if and only if

1. $b_1.\text{EQV}.\text{TRUE}$ for $1 \leq i \leq k$; and
2. $b_x.\text{EQV}.\text{TRUE}$

The logical expression b_1 may involve the current value of $n_1(e)$, which value is represented in b_1 by an asterisk. The logical expression b_x may involve e , which value is represented in b_x by an asterisk. Since more than one entry in list n may meet the condition (b_1, \dots, b_k, b_x) , the entry number " e " is never used explicitly.

The following abbreviations are permitted in the construction of list processing conditions:

1. Omitted expressions are assumed to be TRUE; e.g., the conditions (TRUE, TRUE) and (,) are

equivalent.

2. Commas separating identically true expressions at the end of the condition may be omitted; e.g., the conditions $(b_1, b_2, \text{TRUE}, \text{TRUE})$ and (b_1, b_2) are equivalent.
3. The expression " $*.E.a$," where a is an arithmetic expression, may be represented by " a ."
4. The expression " $*.IS.a$ ", where a is a program object expression, may be represented by " a ."
5. The expression " $IN.a$," where a is an object or class name, may be represented by " a ."

A condition may be restricted by the use of the functions GST and LST. One and only one expression in a condition may be subjected to a GST/LST restriction. Every condition containing GST or LST is met by no more than one entry in list n .

1. $(b_1, \dots, \text{GST}(b_1), \dots, b_k, b_x)$ refers to that entry whose n_1 is the greatest n_1 among all entries meeting condition $(b_1, \dots, b_1, \dots, b_k, b_x)$.
2. $(b_1, \dots, \text{LST}(b_1), \dots, b_k, b_x)$ refers to that entry whose n_1 is the least n_1 among all

entries meeting condition

$(b_1, \dots, b_1, \dots, b_k, b_x)$.

3. $(b_1, \dots, b_k, \text{GST}(b_x))$ refers to the highest numbered entry meeting condition (b_1, \dots, b_k, b_x) .

4. $(b_1, \dots, b_k, \text{LST}(b_x))$ refers to the lowest numbered entry meeting condition (b_1, \dots, b_k, b_x) .

Where expression b_1 is subjected to a GST/LST condition, component n_1 must be of real or integer mode. Where duplicate minima or maxima occur, the lowest numbered entry is chosen.

Place, Place Entry

Execution of the statement

$\text{PLACE}(c_1, \dots, c_1, \dots, c_p) \text{ IN } n$

causes the current value of $\text{LENGTH}(n)$ to be increased by one and the values c_1, \dots, c_j to replace current values of $n_1(\text{LENGTH}(n)), \dots, n_p(\text{LENGTH}(n))$. The number of expressions (p) may not exceed the number of components (k) in list n . Expression c_1 must be of the same mode as component n_1 for $1 \leq i \leq p$.

Execution of the statement

PLACE ENTRY $m(e)$ IN n

is identical in a processing sense to execution of

PLACE($m_1(e), \dots, m_p(e)$) IN n

where p is equal to the smallest number of components contained in either list (m or n).

Remove, Remove Entry

Execution of the statement

REMOVE (b_1, \dots, b_k, b_x) FROM n

will cause all entries meeting condition (b_1, \dots, b_k, b_x) to be removed from list n .

Execution of the statement

REMOVE ENTRY $n(e)$

will cause the e^{th} entry in list n to be removed.

For every entry removed from list n , the value of the function LENGTH(n) is reduced by 1. Rearrangement of the list to eliminate blank entries is performed where necessary.

Replace, Replace Entry

Execution of the statement

REPLACE ENTRY $n(e)$ BY (c_1, \dots, c_p)

causes the values of $n_1(e), \dots, n_p(e)$ to be replaced by the values of expressions c_1, \dots, c_p . The number of expressions (p) may not exceed the number of components (k) in list n . Modes of expression c_1 and component n_1 must match for $1 \leq i \leq p$. The value of $n_1(e)$ before replacement may be represented in expression c_1 by an asterisk.

Execution of the statement

REPLACE ENTRY $n(e_1)$ BY ENTRY $m(e_2)$

causes values $m_1(e_2), \dots, m_p(e_2)$ to replace the current values $n_1(e_1), \dots, n_p(e_1)$, where p is the smallest number of components contained in either list $(m$ or $n)$.

The two statements

REPLACE ENTRY $n(e_1)$ BY ENTRY (e_2)

REPLACE ENTRY $n(e_1)$ BY ENTRY $n(e_2)$

are identical in a processing sense.

Execution of the statements

REPLACE(b_1, \dots, b_k, b_x) BY (c_1, \dots, c_p) IN n

REPLACE(b_1, \dots, b_k, b_x) BY ENTRY $m(e)$ IN n

REPLACE(b_1, \dots, b_k, b_x) BY ENTRY (e) IN n

cause replacement of every entry in list n which meets condition (b_1, \dots, b_k, b_x). Replacement is accomplished in exactly the same manner as by corresponding REPLACE ENTRY statements.

Reset Length

Execution of the statement

RESET LENGTH (n) TO e

will arbitrarily reset the value of function LENGTH(n) to the positive integer value of arithmetic expression e .

Use of this statement is required only when non-list-processing statements have been used to enter values in list n or when the programmer wishes to ignore entries beyond the e^{th} entry.

List Entry Locating Functions

Two MILITRAN functions operate directly upon list processing conditions. These functions are used within the context of an expression as are the functions discussed under EXPRESSIONS.

The functions

MINIMUM INDEX ($n(b_1, \dots, b_k, b_x), s$)

RANDOM INDEX ($n(b_1, \dots, b_k, b_x), s$)

return an integer value designating an entry in the list n which meets the condition (b_1, \dots, b_k, b_x) . If no such entry exists, control transfers immediately to the state-ment labelled s .

The distinction between MINIMUM INDEX and RANDOM INDEX obtains only when more than one entry in list n satisfies condition (b_1, \dots, b_k, b_x) . MINIMUM INDEX chooses the lowest numbered entry meeting the condition; RANDOM INDEX chooses one entry at random from all those meeting the condition.

MINIMUM INDEX may be shortened to INDEX without loss of meaning.

INPUT/OUTPUT

Input/output statements are summarized in this section. They include:

BACKSPACE	READ
BACKSPACE FILE	READWRITE
BINARY READ	REWIND
BINARY WRITE	UNLOAD
END FILE	WRITE
FORMAT	

Logical Unit Designations

Input/output units are designated in MILITRAN source programs as follows:

Tape Units by positive integers;

Line printer by the name PRINTER;

Card reader and punch by the name CARDS.

Tape Control Statements

Statements whose execution causes tape units to perform operations not involving transfer of data are tabulated below. In all cases, the designation *t* is an arithmetic expression.

<u>Statement</u>	<u>Effect</u>
BACKSPACE (t)	Designated tape unit backspaces one record.*
BACKSPACE (t)	Designated tape unit backspaces until an end-of-file mark is passed.*
END FILE (t)	An end-of-file mark is written on the designated tape.
REWIND (t)	Designated tape unit rewinds.*
UNLOAD (t)	Designated tape unit rewinds and becomes inoperative.

- * Statements marked with an asterisk have no effect
if designated tape unit is fully rewound.

Input/Output Lists

Input/output statements which involve transfer of data between the computer and external devices require a list of those items which are to be transferred. All such lists are identically constructed. The summary below utilizes the notation previously used to describe expressions.

$$\begin{aligned} \langle \text{I/O list} \rangle \quad ::= & \quad \langle \text{expression} \rangle \mid (\langle \text{I/O list} \rangle) \mid \\ & \langle \text{I/O list} \rangle , \langle \text{I/O list} \rangle \mid \\ & ((\langle \text{I/O list} \rangle) \langle \text{implied DO loop} \rangle) \mid \\ & \langle \text{I/O list} \rangle , \langle \text{void} \rangle \end{aligned}$$

$$\begin{aligned} \langle \text{implied DO loop} \rangle ::= & \text{FOR } \langle \text{program object} \rangle .\text{IN. } \langle \text{object or} \rangle \mid \\ & \langle \text{single variable name} \rangle \langle \text{object or} \rangle \mid \\ & \langle \text{class name} \rangle \langle \text{terminating condition} \rangle \mid \\ & \langle \text{terminating condition} \rangle , \langle \text{index} \rangle \mid \\ & \langle \text{terminating condition} \rangle , \langle \text{index} \rangle = \langle \text{expression} \rangle \mid \\ & \langle \text{terminating condition} \rangle , \langle \text{index} \rangle = \langle \text{expression} \rangle , \langle \text{expression} \rangle \end{aligned}$$

$$\langle \text{terminating condition} \rangle \quad ::= \text{UNTIL } \langle \text{logical expression} \rangle$$

$$\langle \text{index} \rangle \quad ::= \quad \langle \text{any expression permitted on the left} \rangle$$

$$\quad \quad \quad \langle \text{side of a substitution statement} \rangle$$

Binary Read, Binary Write

The statements

BINARY READ (t) data

BINARY WRITE (t) data

where the "data" is any input/output list, cause reading or writing in binary form on magnetic tape. The expression t must designate a tape unit.

Binary reading and writing are performed without conversion, i.e., items are handled in their exact internal form. Each BINARY WRITE statement writes a logical block of data on tape whose length is dependent upon the number of items in the input/output list. A BINARY READ statement may read only one logical block. If fewer items are read than are contained in the block, the remaining items in the block are skipped.

Read, Write

The statements

READ (t,s) data

WRITE (t,s) data

cause reading or writing of information on the input/output unit designated by the expression t according to a format specified in a FORMAT statement which has the label s. Data must be specified by an input/output list.

The statement

READWRITE(t₁,s₁,t₂,s₂) data

is identical in a processing sense to the statements

READ (t₁,s₁) data

WRITE (t₂,s₂) data

executed in the order shown.

Format

Formats for data transferred by READ, WRITE, AND READWRITE statements are specified by statements of the form

s FØRMAT (Specification)

The label s is required, since it is the only link between the READ or WRITE and its associated FØRMAT.

The specification portion of a FØRMAT statement consists of a series of fields and punctuation marks which indicate the form and placement of data in external records.

Fields are of two types: data and non-data. Data fields specify transmission of data to or from items in the input/output list. Non-data items involve transfer only between the FØRMAT statement and external records. Data fields must be separated from succeeding fields by commas, while non-data fields need not be.

Field groups may be repeated through the use of parentheses. The notation "n(sub-specification)" will cause the group in parentheses to be repeated n times. If n is absent, the group is repeated indefinitely. The sub-specification may not contain parentheses.

The end of any parentheses without a specific number of repetitions (n) normally signifies the end of a record. The specification for the next record starts from the corres-

ponding open parentheses. Additional changes of record may be specified by a slash (/). Two consecutive slashes indicate a blank record.

During execution of a READ, WRITE, or READWRITE statement, input/output lists and FØRMAT specifications are simultaneously scanned from left to right. Each data item in the input/output list corresponds to a data field in the FØRMAT specification, correspondence being established solely by order of occurrence. Transmission ends when the input/output list is satisfied.

Voids in the input/output list cause the corresponding data fields to be skipped (input) or filled with blanks (output). An input/output list which consists solely of an implied "DO-loop" will cause tape motion only if at least one item of data is transferred. If an input/output list results in reading of a partial record, the remainder of the record is skipped.

Non-data fields are designated by the letters X or H. The specification WX causes w characters to be ignored on input or assumed blank on output. The specification WH must be followed immediately by w characters which will be copied literally from FØRMAT statement to record (output) or vice-versa (input).

Data fields are designated by specifications of the form $ncw.d$ where n is the number of fields, c is an identifier designating field type, w is the field width, and d is a supplementary width. The supplementary width is not required for some fields. The number of fields is assumed to be 1 if absent. Basic field types are summarized below. Source and target addresses referred to in the table are items in the input/output list and are discussed in detail immediately following the table. The number of characters in the external record covered by any field is always equal to the field width.

Field
Specification

Interpretation

AW

External field contains alphameric data; internal representation will be BCD code. Input: The rightmost six characters from the field replace data at the target address. If w is less than six, w characters are left justified and filled to six characters with blanks.

Output: Six characters from the source address are right justified in the field. Remaining characters are blank. If w is less than six, the leftmost w characters from the source address are used.

IW

External field contains decimal integer; internal representation is integer data. Input: All blanks are considered zero. Output: Leading zeroes are replaced by blanks.

OW

External field contains octal integer; internal representation is integer data. Input: All blanks are considered zero. Output: Leading zeroes are replaced by blanks.

LW

External field contains word beginning with T or F; internal form is logical. Input: T or F in field results in transfer of TRUE or FALSE to target address. Output: TRUE or FALSE at source address causes T or F to be right justified in field. Remainder of field is filled with blanks.

**Field
Specification**

Effect

Jw.d

External form is the name of an object and its ordinality; internal form is a program object value.

Input: Field is scanned from left to right until w-d characters are read or a left parenthesis appears. Scanned characters (blanks ignored) are compared with names of all OBJECT types in program. Digits following a left parenthesis, or the rightmost d characters, are assumed to be the ordinality. Program object value constructed and transmitted to target address.

Output: Ordinality of source address value is converted to decimal integer, enclosed in parentheses, and placed in rightmost d+2 characters of field. Object name is right adjusted in leftmost w-d-2 characters. Remainder of field is blank.

Jw

Input: Ordinality is assumed unity if no left parenthesis appears.

Output: Only object name appears in field.

Fw.d

External form is decimal number; internal form is real.

Input: Decimal point is assumed d characters from the right unless present.

Output: Decimal point is inserted as dth character from the right.

Ew.d

External form is decimal number and exponent. Internal form is real.

Input: Number is assumed to have the form xxxx+xx where sign separates base value and exponent. Base value times ten to exponent value is transmitted in real mode to target address. Exponent is assumed unity if absent. Decimal point in base value is assumed such that d digits are fractional unless decimal point appears explicitly. Exponent may have one or two digits.

Output: Field has the form .xxxxE+xx, where decimal point falls to the left of the dth character in the base value.

Data fields of type E,F,I, and \emptyset may be signed. Missing sign is assumed plus on input; plus sign is not written on output.

Source and target addresses are determined by items in the input/output list. A source address is a value to be written; a target address is a position into which a value is to be read.

All source addresses yield either the value of an expression or a void. Fields corresponding to voids in the input/output list will be blank.

A target address is implicitly void if the expression corresponding to it contains any operator, external procedure, or open procedure outside of its subscripts. Fields corresponding to voids are ignored.

CONTROL

Statements whose major function is the control of program operating sequence are summarized in this section. They include:

CØNTINUE	IF
DØ	NEXT EVENT
END	NEXT EVENT EXCEPT
END CØNTINGENT EVENTS	PAUSE
END FILE RETURN	RETURN
END RECØRD RETURN	STØP
EXECUTE	UNLESS
GØ TØ	

Go To

Execution of the statement

GØ TØ s

causes the program to continue from the statement whose label is s. In the discussions which follow, this operation will be described as: "Control is transferred to s."

If, Unless

Execution of either of the statements

IF(b),x,y

UNLESS(b),y,x

will transfer control to x if logical expression b has the value TRUE, to y if b is FALSE. The second comma and label may be omitted, in which case the statement immediately following the IF or UNLESS is assumed.

Pause, Stop

Execution of the statement

PAUSE n

causes the computer to stop with the octal number n displayed. Execution may be restarted by manual means. Number n may not exceed 30000 octal.

Execution of the statement

STØP

causes execution of the program to be terminated. Restart cannot be effected.

Execute, Return

The PRØCEDURE statement, described under STRUCTURE, is used to define MILITRAN programs whose operation is to be controlled by other programs. The control statements EXECUTE and RETURN implement control of such programs.

Execution of the statement

EXECUTE n(a₁,a₂,...,a_m)

will cause control to be transferred to the PROCEDURE whose name corresponds to the first six characters of the name n. Arguments a₁,a₂,...,a_m must correspond in mode, type, and order to the dummy arguments of the procedure. The name n is

declared by its appearance in an EXECUTE statement to be an external procedure name.

In a program which is a procedure, execution of the statement

RETURN

will return control to the program in which the EXECUTE statement appears.

Procedures which are used as functions (see under EXPRESSIONS) must return a value to the executing program.

The statement

RETURN e

where e is an expression accomplishes transfer of both control and the value of e.

Do, Continue

Execution of the statement

$$DØ (s) \text{ UNTIL } b, i = e_1, e_2$$

causes iterative execution of statements following the $DØ$ up to and including the statement labelled s . Before the first iteration, index i will be set to the value of expression e_1 ; before subsequent iterations, index i will be incremented by the value of expression e_2 . Index i may be any unsubscripted or subscripted name of type single variable, array, vector, list, or event with list.

If at the beginning of any iteration the value of logical expression b is TRUE, control transfers immediately to the statement following s .

Execution of the statement

$$DØ (s) \text{ FØR } a.IN.b$$

causes iterative execution of statements following the $DØ$ up to and including the statement labelled s . The single variable a must be of program object mode and will successively assume the identity of all members of the object or class b .

When all members of b have been represented by a , control transfers immediately to the statement following s .

In both forms of the DØ statement above it is necessary that the statement labelled s permit control to pass through it to the next statement. Thus the statements GØ TØ, NEXT EVENT, and IF or UNLESS with two labels are prohibited as terminal statements of a DØ loop.

Restrictions on statements terminating DØ loops do not limit the variety of processing arrangements possible, since the statement

CØNTINUE

can be used at any point in a program. This statement performs no operations and requires no space in the computer. Its label, however, may be used to terminate a DØ loop.

Other DØ statements may appear between one DØ and its terminating statement, but the "inner" loop must terminate at or before the end of the "outer" loop.

End, Next Event, Next Event Except

A group of executable statements beginning with one of the statements

CONTINGENT EVENT $n((c_1, c_2, \dots, c_j), d)$

PERMANENT EVENT $n((c_1, c_2, \dots, c_j), d)$

PERMANENT EVENT n

and ending with the statement

END

is known in MILITRAN as an "event." Depending upon the initial statement, the event is either a "contingent event" or a "permanent event."

Events are processed in a sequence determined by the structure of the MILITRAN source program. The "natural" or unmodified sequence is:

1. The first permanent event in the program.
2. Subsequent permanent events in the order of their appearance in the program.
3. The last permanent event in the program.
4. The "next contingent event".

This sequence is repeated until terminated by either failure to select a "next contingent event" or transfer of control to a portion of the program not in any event.

It is not required that a program have any minimum number of permanent or contingent events. In the discussion which follows, we will assume that irrelevant items in the natural sequence are ignored.

Selection of the "next contingent event" is dependent upon the current value of TIME. Of all entries in all contingent event lists, one is selected whose first component exceeds TIME by the smallest positive value. The first component is assumed to be of real mode; duplicate minima within one event cause the entry of least index to be chosen; duplicate minima in more than one list cause an entry to be chosen from the event which appears earliest in the natural sequence.

Execution of the statement

NEXT EVENT

causes control to be transferred to the next event in the natural sequence. If the NEXT EVENT statement is not itself contained in an event, control is passed to the first permanent event.

The statements

NEXT EVENT (n_1, n_2, \dots, n_m)

NEXT EVENT EXCEPT (n_1, n_2, \dots, n_m)

behave exactly as does the NEXT EVENT statement, but modify the natural sequence. NEXT EVENT EXCEPT will assume that events n_1, n_2, \dots, n_m do not exist. NEXT EVENT (n_1, n_2, \dots, n_m) will assume that only the events named in parentheses exist and that they occur in the order listed.

When control is transferred to a contingent event by means of an event sequencing statement, the values of TIME, ATTACKER, TARGET, and INDEX are automatically set. Assuming that control has been transferred to CONTINGENT EVENT n (above) because its i^{th} entry contains the minimum first component, then:

TIME = $c_1(1)$

ATTACKER = $c_2(1)$

TARGET = $c_3(1)$

INDEX = 1

Transfer of values above is made without respect to modes, e.g., ATTACKER is not valid unless c_2 is of program object mode.

End Contingent Events, End File Return, End Record Return

Certain conditions occurring during the running of a program are detected as errors by the program. Three of these conditions are:

1. In attempting to choose a "next contingent event," the program finds no entries whose values equal or exceed the current value of TIME.
2. In reading from magnetic tape, the program encounters an end-of-file mark on the tape before the input/output list is satisfied.
3. In executing a BINARY READ, the end of a logical block is encountered before the input/output list is satisfied. (See under BINARY READ)

In all of the above cases, control is normally wrested from the program and execution is terminated. However, execution of the statements

END CØNTINGENT EVENTS (S)

END FILE RETURN (S)

END RECØRD RETURN (S)

causes the program to be modified in such a way as to return control to the statement labelled s if and when the appropriate error condition occurs.

COMPILER

Statements whose function is providing information to the processor are summarized in this section. These essentially machine-dependent statements are:

END CØMPILATIØN
SUSPEND FAP LISTING

End Compilation

The statement

END CØMPILATIØN

signals the end of a MILITRAN source program. The statement may not contain comments and may not occupy more than one card.

Columns 73-75 of the END CØMPILATIØN card will be preserved and used to identify the translated program.

Suspend FAP Listing

The statement

SUSPEND FAP LISTING

appearing anywhere in a MILITRAN source program will cause listing of the translated program to be omitted by the processor.

APPENDIX

Environment Declarations

REAL $n_1(i_1, i_2, \dots, i_k), \dots, n_m(i_1, i_2, \dots, i_j)$

INTEGER $n_1(i_1, i_2, \dots, i_k), \dots, n_m(i_1, i_2, \dots, i_j)$

LOGICAL $n_1(i_1, i_2, \dots, i_k), \dots, n_m(i_1, i_2, \dots, i_j)$

OBJECT $n_1(i_1), n_2(i_2), \dots, n_m(i_m)$

PROGRAM OBJECT $n_1(i_1, i_2, \dots, i_k), \dots, n_m(i_1, i_2, \dots, i_j)$

CLASS (c) CONTAINS a_1, a_2, \dots, a_m

NORMAL MODE $m_1(a_1, a_2, \dots, a_k), m_2(b_1, b_2, \dots, b_r)$

VECTOR $n((a_1, a_2, \dots, a_1), d_1, d_2, \dots, d_1)$

COMMON n_1, n_2, \dots, n_1

Arithmetic

A = B

Logical

A = B

Control Statements

GO TO s

PAUSE j

STOP

IF (b) s_t, s_f

UNLESS (b) s_f, s_t

DO (s) UNTIL b, $n = e_1, e_2$

DO (s) FOR a.IN.b

CONTINUE

List Processing Statements

LIST $n((c_1, c_2, \dots, c_1), d)$

LENGTH (n)

RESET LENGTH (n) to p

PLACE (e_1, e_2, \dots, e_1) IN n

REMOVE ENTRY $n(k)$

PLACE ENTRY $m(j)$ IN n

REPLACE ENTRY $n(k)$ BY (e_1, e_2, \dots, e_1)

REPLACE ENTRY $n(k)$ BY ENTRY $m(j)$

REMOVE (b_1, b_2, \dots, b_1) FROM n

REPLACE (b_1, b_2, \dots, b_1) BY (e_1, e_2, \dots, e_1) IN n

REPLACE (b_1, b_2, \dots, b_1) BY ENTRY $m(j)$ IN n

MINIMUM INDEX $(n(b_1, b_2, \dots, b_1), s)$

RANDOM INDEX $(n(b_1, b_2, \dots, b_1), s)$

GST

LST

Event Statements

PERMANENT EVENT $n((a_1, a_2, \dots, a_i), d)$
 CONTINGENT EVENT $n((a_1, a_2, \dots, a_i), d)$
 NEXT EVENT
 NEXT EVENT (n_1, n_2, \dots, n_i)
 NEXT EVENT EXCEPT (n_1, n_2, \dots, n_i)
 END
 END CONTINGENT EVENTS (s)

Procedure Statements

PROCEDURE n
 PROCEDURE $n(a_1, a_2, \dots, a_n)$
 EXECUTE n
 EXECUTE $n(a_1, a_2, \dots, a_n)$
 RETURN
 RETURN a

Input-Output Statements

FORMAT (Format Specification)
 READ (t, s) List
 WRITE (t, s) List
 READWRITE (t_1, s_1, t_2, s_2) List
 BINARY READ (t) List

BINARY WRITE (t) List

END FILE RETURN (s)

END RECORD RETURN (s)

BACKSPACE (t)

BACKSPACE FILE (t)

END FILE (t)

REWIND (t)

UNLOAD (t)

Standard Functions

ABS(v)

ATAN(v_1, v_2)

COS(v)

EPSILON(v)

EXP(v)

INTEGER(v)

LOG(v)

MAX(v_1, v_2, \dots, v_j)MIN(v_1, v_2, \dots, v_j)MOD(v_1, v_2)

RANDOM

REAL(v)

SIGN(v)

SIN(v)

SQRT(v)

TAN(v)

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